

Synthesis and Characterization of Hybrid Polymer Composites

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Abstract—The replacement of synthetic fibers by natural fibers paves the way for awareness about environmental degradation and stresses on the need for a constant and reliable development for the betterment of the environment.. Therefore this study is based on fabrication and an investigation on the mechanical properties of animal fiber - plant fiber hybrid bio composites. Out of varied plant and animal fibers, the fibers chosen for this research work are coir and human hair. One of the reasons for selecting hair as the reinforcement material is due to the fact that, human hair is unceasingly produced in large quantity and which becomes a waste in large quantity too. Thus, an effective method should be made to utilize such unceasingly produced waste in a better way. Coir fiber is selected due to its wide range of characteristics. The fabrication can be done by hand layup technique. This technique is utilized to manufacture three samples. First one is coir fiber based bio composite, and second is hair based bio composite and the third sample is a hybrid bio composite made from both hair and coir fiber. The bio composite will be verified under mechanical properties such as tensile strength, compressive strength, flexural strength, impact strength and hardness. Mechanical trials conducted previously have disclosed that coir based bio composite is good in compression, flexural and impact strengths. The Hair based composite also has shown higher tensile strength and higher break load. The three composites possess the same hardness because these fibers constitute the matrix phase which is formed by epoxy resin. Analysis of hybrid composite shows that coir and hair composite constitute mutual properties. Therefore it is a better agreement to include hair fiber in the composite to reduce the overall cost of the composite, as the cost of coir is excess.

Keywords — Coir fiber, Hand lay-up, Human Hair, Hybrid, Mechanical Testing.

I. INTRODUCTION

In the development of modern technology, Fiber Reinforced Polymer (FRP) composites play a vital role in day to day life due to its low cost, processing advantage of lower density and possessing good mechanical

behavior over traditional reinforcement materials. [1-3]. Since from the time of human evolution humans have been using materials to fulfill their needs and comforts and it has been updated into new from time to time, since, it is a need to keep it par with the developing technology which holds many challenging requirements. In order to cope up with the rising challenges, the materials are expected to have several unique features. Primarily, the materials should possess complex performance efficiency and reliability. Secondly, the materials should contain less weight as possible. Thirdly, the material must be a combination of many properties, thus it can remain neutral without limited by any particular application. The above discussed requirements can be fulfilled only by the composite material and the replacement of synthetic fiber by natural fibers can avoid environmental degradation, so it is a boon to the nature too. Commonly plants and animals are the major sources of natural fibers but plant based (cellulose) composites are widely accessible for research work compared to animal fibers. Renewable natural fibers such as oil palm, flax, and pineapple leaf can be used to acquire high performance polymer materials. The renewable natural fiber as reinforcement for polymer is a sustainable choice to the environment [4-7]. But this research work is based on animal fiber based composite because coir, one among other animal fibers possesses major extensive properties both mechanically and physically. And also the Human hair is prominently used in this research to devise a new effective method that can be used in fabrication. The coir and human hair serve better use because the usage of fillers in this material is restricted. Filler materials are generally used in composite materials to increase the possessions of the material. But in most of the cases they tend to reduce the volume fraction of the resin which constitutes the matrix phase and it also reduces the mechanical properties of the material. Therefore fillers are highly restricted and this work mainly concentrates on identifying the mechanical components of coir and human hair fiber based composites which can be used in the replacement of metals in certain high performance materials.

II. MATERIALS

The raw materials included in the fabrication are Epoxy resin LY 554, Human hair Fiber, Coconut coir fiber, Hardener, and Mansion Wax. Human hair Fiber, Coconut coir fiber must be alkali-treated in 2% of NaOH solution from 10 min to 30 min to remove any oily material and hemi cellulose, and then must be dehydrated in sun light.

2.1 Coir Fiber

The coir fibers are first battered with 2% of detergent solution for one hour and washed with distilled dihydrogen monoxide and then it is sanctioned to dry in an air oven at 700c. Then these dried fibers are to be treated with sodium hydroxide solution. The NAOH commixed solution should be kept in the oven for the second time at 780c for 3 hours. Subsequently the treated fibers must be cautiously washed with dilute acid in order to abstract the alkali particles and then let it for final dehydration.



Fig.1: Coir Fiber

2.2 Human Hair Fiber

Human hairs constitute several components and the compositions are as follows. It constitutes proteins of 65-95% by weight, 32% dihydrogen monoxide and the rest is occupied by lipid pigments and other compounds. Keratin is the main occupant of human hair is a type of protein that is virtually 80% responsible for the formation of hair [8]. Structural analysis of hair shows that, it consists of three different layers such as cuticle, cortex and medulla. The surface properties of hair depend on the cuticle which forms the outermost layer by cross linked cystine [9].



Fig.2: Human Hair Fiber

The medulla contains highly concentrated lipid and less cystine and it is in the form of cylinder which forms the innermost hair thread. Utilization of hair as a reinforcement material is an incipient endeavor as it evolves an incipient method to utilize the material which is available in immensely colossal quantities. It can be used as a reinforcement material because it can resist stretching and compression [10]. Investigation on the mechanical properties of fiber composites can be done and it can be concluded that hybrid composites exhibit high vigor.

2.3 Resin and Hardener

The matrix phase binds the sundry layers of the fibers and it is constituted by epoxy resin, to amend the remedying rate 1 part of hardener is integrated to 10 components of resin. The commercial grade of resin used is Araldite LY554 and hardener used is amino hydrocarbon.



Fig.3: Resin and Hardener

III. FABRICATION PROCEDURE

The fabrication procedure is done utilizing the hand layup technique. For the fabrication of coir fiber, the following procedures are handled. First the coir fibers should be cleaned exhaustively and dried in shade. At the commencement of fabrication, the mould from the coir must be cleaned and kept dust free. Then a layer of Poly Vinyl Alcohol must be applied on the mould surface, so that it can facilely abstract the laminate after fabrication.

After that the epoxy resins (Araldite LY554) and hardener (amino hydrocarbon) should be commixed together in a proportion of 10:1. Then the resin should be applied in the mould utilizing a brush and the coir threads are laid on it horizontally. Caution about overlapping of fibers must be taken, as it can lead to the variation of thickness of the culminated composite. The roller can be acclimated to set the coir fibers firmly over the antecedent layer of resin and shuns air bubbles between.

Table.1: Orientation of fiber in composites

Sample A	Coir-horizontal	Coir - vertical	Coir-horizontal
Sample B	Hair-horizontal	Hair-vertical	Hair-horizontal
Sample C	Coir-horizontal	Hair vertical	Coir-horizontal

Then a double coating of resin must be given to the coir layer with the avail of a brush. Once more the same amount of coir fibers should be laid over the resin layer, in a vertical direction. This can be done to increment the overall vigor of the composite because transmutation in orientation has the competency to sentinel the material from the propagation of applied forces. The laminate must be then sanctioned to alleviate for duration of one hour. A force must be given on the surface of the composite to evade it from the formation of air bubbles. Conclusively it's consequential to ascertain that the resin has alleviated and after that it must be punctiliously abstracted from the mould and cut into required dimensions. The same procedure must be followed for all the samples. Three samples should be fabricated with the same procedure having fibers in different orientation as shown in Table-1.

IV. TESTING OF COMPOSITES

4.1 Tensile Test

Tensile test is one of the most widely used tests by the researchers to resolve the tensile properties. Tensile test must be done according to the format of the American Society for Testing and Materials (ASTM) specified test specimens. In the present examination, the tensile testing machine is Associated Scientific Engg. Works, FIE group of India which is provided with gear rotation speed of 1.25, 1.5 & 2.5 mm /min and it can be tested for a maximum load of 5 tons. Tests can be repeated on specimens achieved from three samples which are made with Coir, Hair and a hybrid of Coir-Hair. Tensile force is applied at the cessations by clamping the specimen in the UTM. The tensile breaking load consequent to each sample is attained. And the variation of tensile stress with strain can be plotted.



Fig.4: Tensile testing machine used in the present investigation

4.2 Compressive Test

For the tensile test a standard piece of laminate must be cut predicated on ASTM standard. The test is done in a FIE group of India, at room conditions. Tests are reiterated on specimens obtained from three samples made with coir, hair and a hybrid of coir-hair. Compressive force is applied at the terminuses by clamping the specimen in the UTM. The compressive breaking load consequent to each sample is attained. And the disparity of compressive stress with strain can be plotted.

4.3 Flexural Test

For the flexural test a standard piece of laminate must be cut predicated on ASTM standard. The test is done in a FIE group of India, at room conditions. Tests are reiterated on specimens obtained from three samples made with coir, hair and a hybrid of coir-hair. Flexural force is applied at the terminuses by clamping the specimen in the UTM. The flexural breaking load corresponding to each sample is obtained and the disparity of flexural stress with strain can be plotted.

4.4 Impact Test

Impact test gives extreme energy to the material. And this impact test can be done in a Charpy Impact Machine of ASTM standard. The samples for this test must be cut according to the standard dimensions. The specimen relents to the heavy blow obtained by the hammer and the blow which it fails to withstand gives the impact energy. Tests must be reiterated on specimens obtained from the three samples that are made with Coir, Hair and a hybrid of Coir-Hair.

4.5 Hardness Test

The Hardness Test estimates the indentation rigidity of polymer predicated materials. The test is done as per ASTM standard. The specimen must be indented utilizing a hardened steel indenter with certain force and geometry.

V. RESULT AND DISCUSSION

5.1 Tensile Properties

The fabricated sample must be tested as per the ASTM standard. The composites such as hair, coir and Coir-hair

hold varied tensile strength and that are shown in figure 6. The tensile strength of the coir, Hair, and Hybrid composite fiber varies from 16 MPa to 19 MPa.

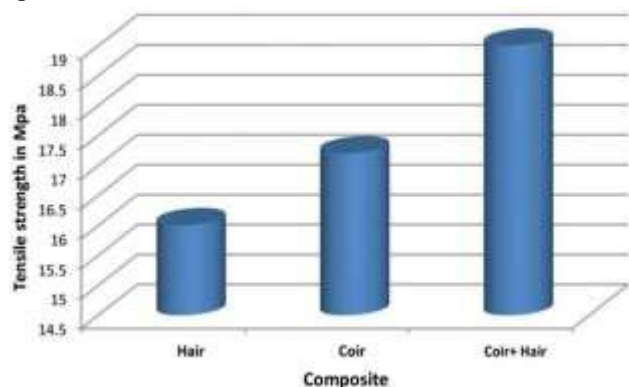


Fig.5: Tensile Properties

These outcomes clearly indicate the gradual increase of tensile strength for hair fiber more than the hybrid fiber. Comparable remarks are reported by Noorunisa Khanam et al. [11]. From this fig, it is conspicuous that the hybrid composite holds better tensile properties. This is because, the tensile vigor depends on the cross section area of the specimen and the modulus depends on the elongation percentage of the specimen. So these two parameters are liberated from each other and the elongation percentage is superior only for the hybrid composite. Consequently it's clear that the hybrid composite can endure more tensile load than the other two composites afore failure.

5.2 Compressive Properties

The Compressive Test can be done as per the ASTM: D695 standard and the variation in compressive strength of the composites which are alkali treated are shown in figure 7.

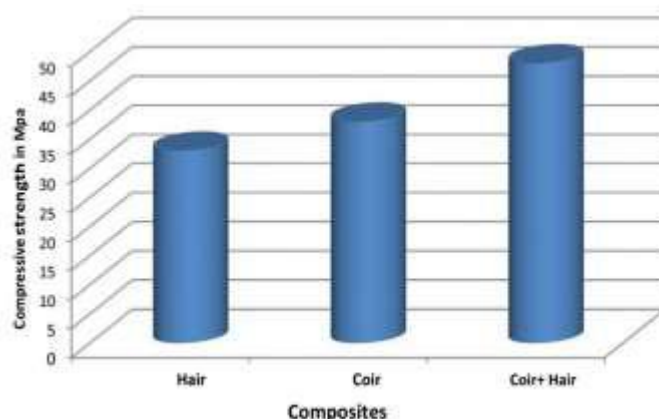


Fig.6: Compressive Properties

The composite materials must be tested and the compressive strength must be calculated. Three specimens of different fiber volume fractions and average compressive strength must be tested and reported. The compressive strength increases in the hybrid composite and the compressive strength of the Hair, Coir and Hybrid

composite fiber varies from 33 MPa to 48 MPa. The result of this test display that, the hybrid composite has superior properties compared to all the other parameters calculated.

5.3 Flexural Properties

Flexural test can also be called as bend test, and this test must be done with the appropriate fixture as per the ASTM-D 790 (0.125" x 0.5" x 5.0"). This test must be steered in the macrocosmic testing machine in a compression mode. First the sample must be placed on the bending fixture and the compressive load must be given under concrete conditions. During this function a curve will be engendered till the failure of the sample. The varied flexural strength of the three composites such as hair based, coir based, Coir-hair based samples are shown in figures 8. The flexural strength of the Hybrid composite fiber is 56 MPa. From these results, it is conspicuous that the hybrid composite holds better flexural properties.

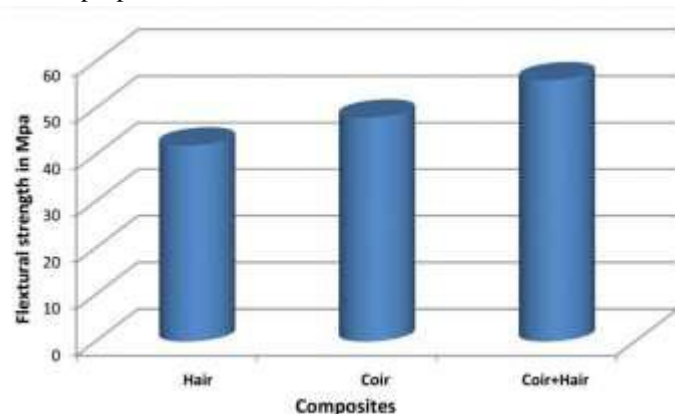


Fig.6: Compressive Properties

A. Impact Properties

To conduct the impact test, Charpy impact machine must be utilized. The result of the impact test is shown in fig .The impact vigor must be calculated from the energy engrossed by the specimen when exposed to a heftily ponderous blow. Resin toughness determines the impact vigor, rather than the fiber stiffness. The stacking system of the fibers plays a paramount role and integrates to the impact properties of the laminate because, the crack propagation is fortified by the alteration in the fiber placement thus incrementing the impact vigor of the specimen.

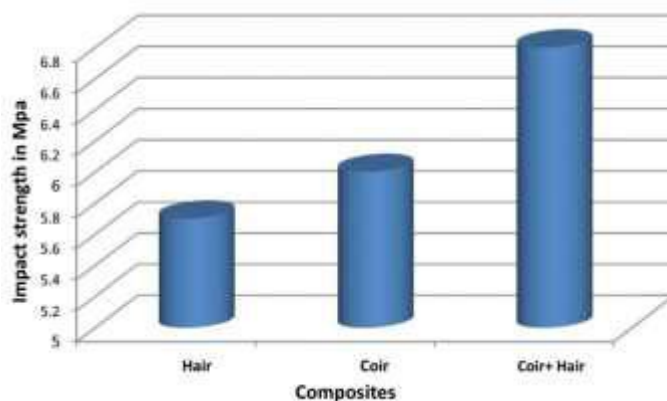


Fig 6: Compressive Properties

The maximum impact strength of the composites varies from 5.7 MPa to 6.8 MPa. Alkali treated coir fibers and Hair fibers show improved impact strength. This result is par with the findings of Varada Rajulu et al[12] and Ramachandra reddy et al [13] who have carried out research on characterization of bamboo composites. The results of this test display that the hybrid composites enhance good impact compared to the other composites.

B. Hardness

The hardness test must be conceded in a Shore Durometer. The samplings must be cut into dimensions as per the ASTM standard. The Results of this test are charted in Table-2 and the rigidity of the Hair based, Coir based and Hybrid composite varies from 624 to 683. The result of this test displays that, the hybrid composite has superior properties compared to all the other parameters calculated.

Table.2: Hardness Properties

Sample	Location 1	Location 2	Average
Coir	420	510	465
Hair	550	472	511
Cor+Hair	624	742	683

VI. CONCLUSION

The present investigation of mechanical properties of human hair, Coir, Hybrid (Human Hair + Coir) fiber reinforced epoxy resin composite leads to the following Conclusion. The value of tensile strength is increased from 16 to 19 MPa and the compressive strength of the Hair based, Coir based, and Hybrid based fiber varies from 33 MPa to 48 MPa. The flexural strength of the Hybrid composite fiber is 56 MPa and the maximum impact strength of the composites varies from 5.7 MPa to 6.8 MPa.

- The natural fiber/epoxy approach has been made use of in order to make cost effective composite.
- In the present the work human hair fiber reinforced epoxy resin composites have been successfully fabricate by simple hand lay process.

- It has been noticed that mechanical properties composites such as tensile strength, compressive strength, flexible strength, Impact Strength and hardness of the composite of found out varies specimen by varying fiber.
- Hybrid composite of Hair-Coir composites accommodate good properties according to the capacity of the individual composite opted for.
- Human hair holds better mechanical properties compared to other composites but when Human hair is comprised with Coconut coir fiber the composite material gets better mechanical properties.

Thus it's vitally obvious that Eco – friendly Human hair and coconut coir influence superior mechanical properties.

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